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ORIGINAL ARTICLE

Usefulness of Tei index in patients with rheumatic mitral regurgitation and apparently normal left ventricular ejection fraction

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Abstract *Background and aim:* Rheumatic mitral regurgitation is rather common in developing countries. It usually progresses insidiously, because the heart compensates for increasing regurgitant volume by left-atrial enlargement, causes left-ventricular overload and dysfunction, and yields poor outcome when it becomes severe. Doppler-echocardiographic methods can be used to quantify the severity of mitral regurgitation. It is known that ejection fraction underestimates the presence of left ventricular dysfunction in these patients. This study aimed to study global cardiac function of these patients by using LV Tei index.

Methods: One hundred patients with rheumatic mitral regurge predominantly were included (40 males and 60 females; aged 10–24 years, median 20.6 years). All participants were subjected to full echocardiographic study including total isovolumic index (Tei index = isovolumic relaxation time IRT + isovolumic contraction time ICT/ejection time ET) for the left ventricle. Special attention was paid to grading of severity of the mitral regurgitation.

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Results: LV ejection fraction was preserved in all cases but, however, the total left isovolumic index was prolonged 0.56 ± 3 in 64 of them (34 females and 30 males) denoting masked LV dysfunction $P < .00001$. There was a correlation of increasing severity of dysfunction with the degree of mitral regurgitation.

Conclusion: Ejection fraction underestimates the presence of left ventricular dysfunction in these patients. However, this was unmasked by the Tei index which could be an additive data for detecting early left ventricular dysfunction.

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1. Introduction

Rheumatic mitral regurgitation (MR) is common in developing countries and the severity of regurgitation tends to increase with age (Braunwald, 1969).

Due to adaptive remodeling of the left ventricle and atrium and patient adaptation to the disease, patients can remain asymptomatic or minimally symptomatic for prolonged periods, even in the presence of severe MR. However, there is an annual change in the effective regurgitant orifice and thus a change in severity is noticed as well as progressive LV remodeling, leading eventually to the development of LV dysfunction, which may be irreversible (Braunwald, 1969). Another major concern for patients with asymptomatic severe MR is the risk of sudden cardiac death, with an absolute risk of 1–2.5% over 6 years. The major determinants of sudden cardiac death in MR are LV dysfunction, redundant leaflets and severe MR (Enriquez-Sarano et al., 1999).

The major challenge for the clinician is to detect LV contractile dysfunction at an early or subclinical stage so that surgical correction can be instituted to prevent the development of irreversible LV dysfunction (Lee and Marwick, 2007).

Although LV ejection fraction (EF) is the most powerful predictor of post-operative LV dysfunction and subsequent cardiac morbidity and mortality it is influenced by alterations in heart rate and loading. While a reduced EF portends a poor prognosis, the converse is not true, as irreversible LV dysfunction may develop insidiously in the asymptomatic patient, and may be “unmasked” only after successful surgical correction of the MR, resulting in significant post-operative cardiac morbidity and mortality (Enriquez-Sarano et al., 1994; Grigioni et al., 1999).

Most standard echocardiographic parameters including EF and LV dimensions are pre-and after-load dependent, and their evaluation is influenced by the hemodynamic milieu of MR. A variety of echocardiographic and invasive hemodynamic parameters are useful in detecting subclinical LV dysfunction preoperatively in asymptomatic patients and may predict outcome following mitral valve surgery. However, most of these techniques have limitations which may reduce their general applicability (Bonow et al., 1998). Enlargement of various resting LV dimensions (e.g. LV end-systolic diameter) is already accepted as a firm indication for surgery. However, this may not be as useful now, as an LV end-systolic diameter ≥ 4.5 cm is rarely seen in asymptomatic patients currently presenting for decisions regarding surgical intervention. LV dp/dt , derived from the continuous wave spectral Doppler pattern of the MR jet, is less load dependent than some standard echocardiographic markers. However, this may be difficult to obtain accurately from eccentric regurgitant jets (which are common in degenerative mitral valve prolapsed).

Markers of LV contractile function such as LV end-systolic wall stress/end-systolic volume ratio and peak elastance are load independent and considered by some to be the “gold standard”. Traditionally, these have been measured invasively, which is unattractive for a test for clinical follow up of these patients. While these parameters have been shown to provide prognostic information when measured non-invasively the LV systolic pressure measurement may not correspond to peripheral pressure and, therefore, the parameters may not provide the same information as they have in the literature (Otasevic et al., 2006).

There is, therefore, a need for an easily measured, accurate, reproducible, and preferably load independent echocardiographic parameter to assist the clinician which identifies high risk patients who may benefit from surgery, and optimize the timing of surgery.

2. Patients and methods

This prospective study included 100 patients with rheumatic mitral regurge. All patients were in sinus rhythm. Diabetics and hypertensives were excluded. All patients have mainly mitral regurge while only 21 (14 females and 7 males) have associated mild mitral stenosis. None have associated aortic valve disease. All participants were subjected to full echocardiographic study including left ventricular diastolic and systolic functions, and the combined index of myocardial performance (Tei index = $IRT + ICT/ET$).

Two-dimensional and Doppler echocardiography studies were performed by using a commercially available Hewlett–Packard (Andover, Massachusetts) instrument (sonos 1500) with a 3.5 MHz transducer.

Images of the heart were obtained in multiple cross sectional plans by using standard transducer position. M-mode echocardiograms were derived from two-dimensional images under direct anatomic visualization and were recorded at 100 mm/s.

The following measurements were assessed:

1. Left ventricular end-systolic diameter (LVESD).
2. Left ventricular end-diastolic diameter (LVEDD).
3. Left ventricular posterior wall thickness at end-diastole (PWT).
4. Inter ventricular septal thickness at end-diastole (IVS).

The following parameters were calculated:

1. LVESD index (LVESDI) = $LVESD/BSA$.
2. LVEDD index (LVEDDI) = $LVEDD/BSA$.
3. Left ventricular end systolic volume (ESV) by cubing LVESD.

4. Left ventricular end-diastolic volume (EDV) by cubing LVEDD.

Left ventricular ED and ES volumes were calculated from the apical 4-chamber view using biplane Simpson's rule and indexed to the body surface area, and left ventricular ejection fraction was calculated using the area-length method, or the ratio of EDV-ESV/EDV and expressed in percentage.

$$\text{Ejection fraction (EF)} = \text{EDV} - \text{ESV} / \text{EDV} \times 100$$

5. Functional ECHO findings including Tei index, EF% and E/A.
6. The isovolumetric relaxation time (IRT) was measured with the pulsed wave sample volume placed between the mitral inflow and the left ventricular outflow tract. The Tei index was obtained as the sum of both contraction and relaxation iso volumetric periods, divided by the ejection time. These Doppler time intervals were measured from mitral inflow and left ventricular outflow velocity spectral signals (Fig. 1). The interval (a) [from the cessation to the onset of mitral inflow] is equal to the sum of iso volumetric contraction time (ICT), ejection time (ET), and IRT. The interval (b) represents the ET, obtained at the left ventricular outflow tract. Thus, the sum of ICT and IRT was obtained by subtracting (b) from (a). The Tei index of myocardial performance was calculated as (a - b)/b.

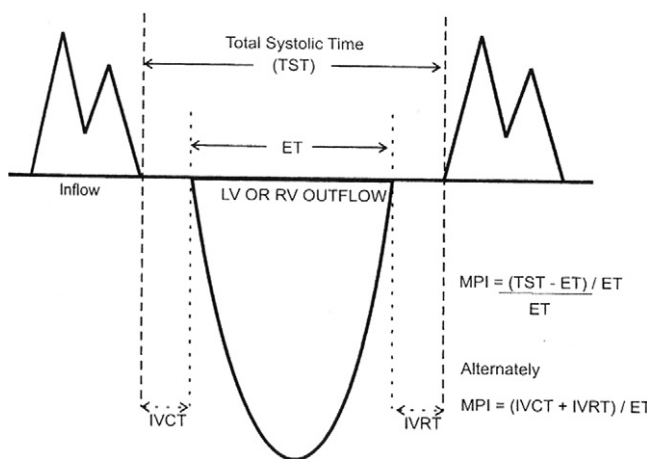


Figure 1 Doppler time intervals included in the Tei index.

3. Results

This study consisted of 100 patients with rheumatic mitral regurg with age ranges from 10 to 24 years and sex including 60 females and 40 males. They underwent routine echocardiographic and Doppler studies.

The major findings of the present study are that LV ejection fraction was preserved in all cases but, however, the total left isovolumic index was prolonged 0.56 ± 3 in 64 of them (34 females and 30 males) denoting masked LV dysfunction $P < 0.001$. There was a correlation of increasing severity of dysfunction with the degree of mitral regurgitation, see Table 1.

4. Discussion

The index is simple, noninvasive, easy to estimate and reproducible. The index is a Doppler-derived time interval index that combines both systolic and diastolic cardiac performance. In the presence of MR, LV loading conditions are modified with a trend to increase preload and decreased after load (Braunwald, 1969). Under these hemodynamic conditions, the assessment of myocardial contractility by ejection phase measurements is inappropriate, as these are well-known to be influenced by acute changes in loading conditions. It has been demonstrated that ejection fraction decreases after surgical correction of MR (Okita et al., 1993; Wisenbaugh, 1988).

Currently, standard gray-scale ultrasound parameters reflecting global LV systolic function, such as LVEF, end-systolic short-axis diameter (ESD), and end-diastolic short-axis diameter (EDD)s are used in clinical practice to monitor LV function in patients with volume overload. However, these volume-based functional parameters have important limitations in assessing myocardial contractile function where either regurgitant volume (RV) or increased cavity pressure can mask any underlying changes in myocardial force development.

We assumed that the Tei index would be a useful tool in the assessment of systolic function in the presence of MR. the LV load independence of this myocardial global index remains to be a subject of controversy in the literature. Some authors clearly reported that Tei index is weakly influenced by changes in loading conditions and heart rate in clinical settings (Poulsen et al., 2000; Eidem et al., 2000). Lutz et al. (2003) found that Tei index is only affected by the increase in preload in mechanically ventilated patients. Similarly, Moller et al. (1999) reported that Tei index is only affected by changes in load conditions in healthy volunteers. Under experimental conditions, in which a large magnitude of loading changes may be induced, other authors have clearly demonstrated the load-dependence of the Tei index (Cannesson et al., 2006; Haney, 2007).

Table 1 Functional echocardiographic findings in patients with rheumatic mitral regurge.

| Groups/parameters | Patients with grade I-II/IV mitral regurge | | Patients with grade III-IV/IV mitral regurge | | P value |
|-------------------|--|--------|--|--------|---------|
| | Mean | ± S.D. | Mean | ± S.D. | |
| EF% | 67.7 | 6.5 | 69.5 | 4.9 | 0.341 |
| Tei index | 0.45 | 0.89 | 0.58 | 0.7 | 0.001* |
| E/A | 0.9 | 0.3 | 0.8 | 0.4 | 0.411 |

EF% = Ejection fraction percentage.

* Significance at <0.05 .

We have compared the ability of ejection fraction and the Tei index to assess the systolic function in patients with MR. We concluded that ejection fraction underestimates the presence of left ventricular dysfunction in these patients. However, this was unmasked by the Tei index which could be an additive data for detecting early left ventricular dysfunction.

Currently, it may not be feasible to replace ejection fraction by the preoperative Tei index as this parameter is still not widely used in clinical practice despite the abundant literature available.

The following point must be considered in the assessment of the clinical relevance of our study, the postoperative LV function after valve surgery and to establish an accurate correlation between Tei index and the postoperative ejection fraction.

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